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A Process Flow Based Design Model Using Aspect Based Reusability

G. Shanmugasundaram[1,*], V. Prasanna Venkatesan[1], C. Punitha Devi[2]

[1]Department of Banking Technology, Pondicherry University, Puducherry, 605014, India
[2]Department of Computer Science & Engineering, Pondicherry University, Pondicherry, 605014, India

Abstract Reusability is an effective quality measure, which defines the degree of usage/applicability of design or code on development of various applications. The Aspect oriented paradigm is one kind of mechanism to achieve reusability because it provides the systematic ways in identifying and separating the crosscutting concerns. In general any system can be defined as set of processes. These processes have many crosscutting concerns (aspects) that need to be separated to identify the reusable entities. The objective of this work is to identify the reusable entities with the help of a process flow based design model that mines the crosscutting concerns and separates them from the original processes. These reusable entities reduce the development effort. Also, we assess the reusability based on the metrics defined by us and they are reported. Banking Loan System has been chosen as a case study to demonstrate the working of the proposed process flow based design model. The quantified results of this model show the achievement of reusability and reduction of effort on development.

Keywords Reusability, Aspect Oriented Reuse, Reusability Model, Aspect Based Model, Process Level Reuse, Reusability Assessment

1. Introduction

Software Reuse is an important area of software engineering research that promises significant improvements in software productivity and quality[1]. Reusability is the extent to which a component can be reused and reduces the cost in developing software by facilitating less coding and more integration. Reusability can be achieved through various paradigms. Aspect based reusability is one of such a kind. Any software system is composed of much functionality, which is represented through various processes. These processes have one or more crosscutting concerns. Mining and separating those concerns is a complex task. The programming paradigm like Object Oriented, component oriented programming paradigm, aspect oriented is a promising paradigm to promote improved separation of concerns, leading to the production of software systems that are easier to maintain and reuse[5][7][3]. So the metrics used to compute reusability of different systems like object oriented, component based and service oriented having relation to one another (i.e. object oriented reusability metrics used to measure reusability of component based and service oriented systems)[10].

This paper presents a process flow based design model to increase the level of reusability and reducing effort involved in software development. Further flow of this paper is organized as follows: section 2 discusses the related works and section 3 presents the process flow based design model. Section 4 demonstrates the working of process flow based design model by using case study. The section 5 presents the discussion. The conclusion of this work is given in section 6.

2. Related Works

Aspect-oriented techniques rebound to improving the design level of software, the reusability of components and the implementation of separation of concerns[6][8]. Aspects will help to better understand the software system and strengthen the qualities like adaptability; maintainability and reusability of the software. Few authors have proposed quality model and few others have proposed metrics suite for measuring the reusability which are briefed below.

- Thiago Gottardi[2] proposed the two new model diagrams: a diagram for reuse requirement documentation and a diagram supporting graphical cross cutting framework reuse.
- Cláudio Nogueira Sant'Anna et al.,[3] proposed assessment framework for AOSD, which is composed of two Components: a metrics suite and a quality model. These components are based on well known principles and existing metrics in order to avoid the reinvention of well-tested solutions. The metrics suite captures information about the design and code in terms of fundamental software attributes such as separation of concerns, coupling, cohesion and size.

* Corresponding author:
sundar_gss2004@yahoo.co.in (G.Shanmugasundaram)
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- Uwe Hohenstein and Daniel Wiese[4] used Aspect J based approach for presenting more reuse on infrastructure components.
- Jacques Klein and Jörg Kienzle[9] proposed an approach for specifying reusable aspect models that define structure (using class diagrams) and behavior (using sequence diagrams). They demonstrated the high degree of reusability of their aspect models by modeling 8 inter-dependent aspects of the Aspect Optima case study.

From these literature reviews, we can find that few works have focused on aspect based quality model to improve reusability of the systems and others contributed their work towards metrics for measuring the reusability by using cross cutting concerns. This indicates that there is no comprehensive mechanism or approach to achieve the reusability of the system based on aspect oriented approach. This factor motivated us to propose this Process flow based Design model.

3. Process Flow based Design Model Proposed Work

The proposed model uses crosscutting concerns to prove the significance of reusability in reducing development efforts involved in creating new software systems using a design walkthrough This model has been carried out through four phases as shown in figure 1 and starts with phase I which defines the process flow of the system. The Phase II separates the crosscutting concerns from the major set of processes. Third Phase measures the intra application reusability. Finally phase IV reports the efforts taken and states the reduced development efforts brought out by this model.

3.1. Process Involved in Various Phases

3.1.1. Defining Process Flow

The initial phase starts by representing the processes flow of a system which clearly lists the steps or process to carry out the services. To define the process flow of the system tabular representation has been used. The processes of the system are further divided into one or more sub-processes which in turn consist of one or more tasks. The output of this phase shows complete process flow of the system in both macro (sub-process) and micro (task) levels.

3.1.2. Aspect Miner

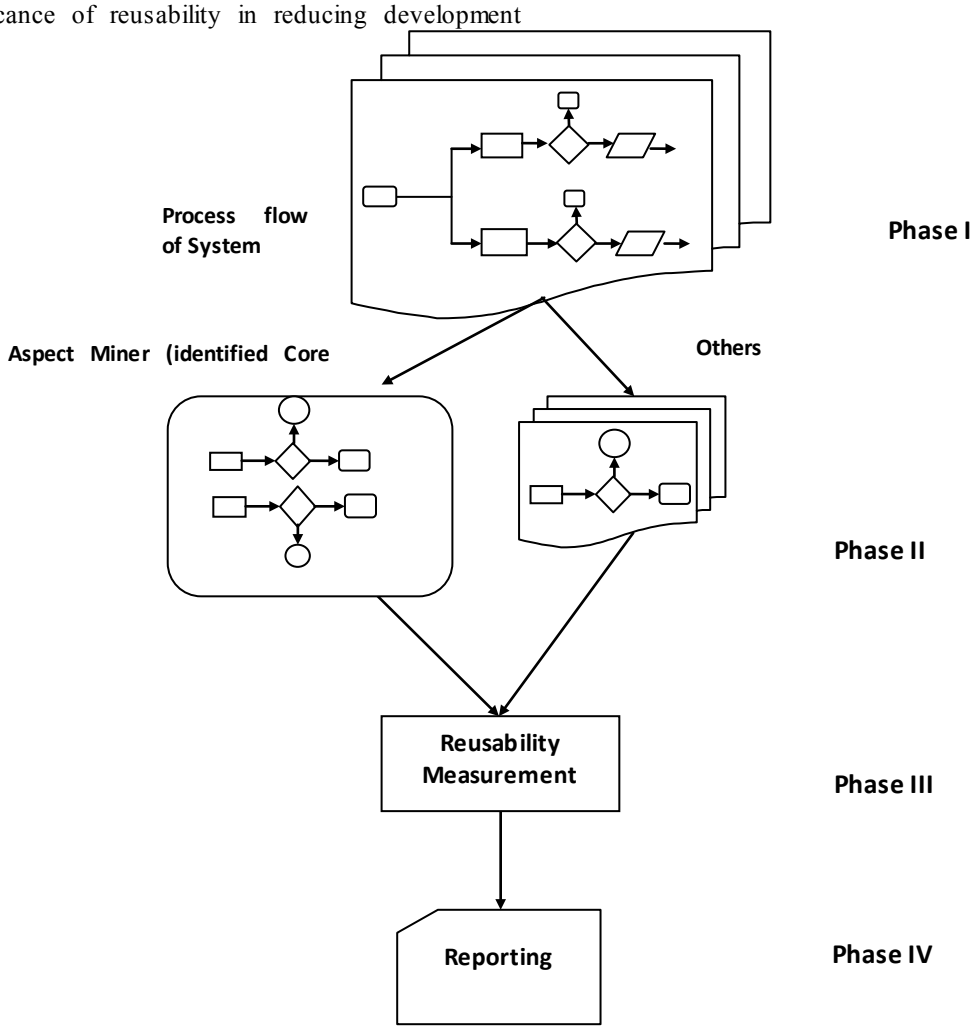

Figure 1. Process Flow based Design Model

The Crosscutting concerns from the process flow of the system are mined and extracted by design walkthrough and illustrated via tabular representation. To differentiate the crosscutting concerns from other tasks the processes are represented using gray shade. The aspects are identified in each sub-process of different processes of the system and are mapped precisely. Separation of the concerns from the original processes of the system is done in phase II.

3.1.3. Reusability Measurement

Measuring the Reusability of the system has been done with four measures. These four measures are task, sub-process, process, and system level reusability. In this phase the metrics are defined for the above said measures and they are used for calculating the reusability level respectively.

To measure the reusability of the system, the following four metrics are proposed. All metrics units are represented in terms of percentage.

- Task WISE REUSE (TWR)

$$\text{TWR} = \left(\frac{\sum_{i=1}^{n} T_i}{TP} \right) 100$$

Where,

T_i = Number of tasks cross cutting on different Processes

TP = Total Number of Processes

- Sub-process WISE REUSE (SPWR)

$$\text{SPWr} = \left(\frac{\sum_{j=1}^{m} SPa_j}{\sum_{k=1}^{l} Tspt_k} \right) \times 100$$

Where,

SPa_j = Number of aspects used in particular sub-process of different processes

Tt_k = Total Number of Tasks involved in particular sub-process of different processes

- Process WISE REUSE (PWR)

$$\text{PWR} = \left(\frac{\sum_{e=1}^{m} Ta_e}{\sum_{k=1}^{l} Tt_k} \right) \times 100$$

Where,

Ta_e = Total Number of aspects identified in particular processes of entire system

Tt_k = Total Number of tasks involved in particular Processes of entire system

- Overall System REUSE (OSR)

$$\text{OSR} = \sum_{r=1}^{z} \left(\frac{\sum_{e=1}^{m} Ta_e}{\sum_{k=1}^{l} Tt_k} \right) \times 100$$

Where,

OSR is the summation of process wise reuse

Reporting/Finding

Final phase of the model reports the outcome of the proposed process model by showing the reusability gained at different levels i.e. task, sub-process, process and the entire system. It gives a clear view about total efforts saved by adopting aspect oriented approach for developing software system.

4. Case Study

For evaluating our proposed model we have used banking loan system based on State Bank of India[11]. The Loan System has different category like vehicle, car, and housing and education loan. Each loan has number of steps to cross for completing the process. Each loan has various sub process, which comprises of several task[12].

We start the evaluation by defining the process flow of different categories of loan in tabular representation as shown figure 2 and we used gray shade to represent aspects identified in all sub process of various loan processes and computed into values as shown in the figure 2.

4.1. Reusability Measurement in Different Levels of Loan Processes

4.1.1. Task Wise Reuse (TWR)

The metric TWR is used to compute reuse of the cross cutting tasks in different loan processes. Here the

Number of loan processes chosen is four. The following table I reveal the computed results of the chosen four loan processes.

The table 1 gives aspects which are identified by aspect miner for the various loan processes. We have identified 33 cross cutting tasks as aspects in the different loan processes and most of them are falls in all loan processes.

4.1.2. Sub-Process Wise Reuse (SPWR)

By applying the SPWR metric ,the sub process wise reuse of various loan processes can be computed and result are shown in table 2. In table 2, loan processes of different category are split into seven sub process which is common to various loan processes. In each sub-process, the cross cutting tasks are identified and which are summed into values. For computing the SPWR the summed values are used as numerator and total numbers of tasks involved in sub process of various loan processes are used as denominator. The SPWR is computed for seven sub processes of different category of loans.

4.1.3. Process Wise Reuse (PWR)

The process wise reuse (PWR) metric is computed as the ratio of Number of tasks involved in the particular loan Processes to Number of tasks to be identified as cross cutting tasks in particular loan Processes. The table 3 gives information about the types of loan and number of tasks involved in the different categories of banking loan system. After the identification of aspects or core assets in each category the process wise reuse of different category of loan are computed. The result of this metric show how much of effort involved in the bank loan system is greatly reduced. For example in home loan, effort saved by using the cross cutting tasks are 73.33%, the remaining 26.66% effort are need to be developed.

Home		Car		Education		Business		Mapped
Application		Application		Application		Application		
	PERSONAL INFORMATION OF THE APPLICANTS	PERSONAL INFORMATION OF THE APPLICANTS		PERSONAL INFORMATION OF THE APPLICANTS		Business Information		3
	FINANCIAL / INCOME INFORMATION	FOR SELF- EMPLOYED PERSONS		FINANCIAL / INCOME INFORMATION OF THE PARENT / G		Principal(s)/Guarantor(s)		2
	EMPLOYMENT DETAILS OF THE APPLICANTS	DETAILS OF BANK ACCOUNTS		EMPLOYMENT DETAILS OF THE PARENT / GUARDIAN		PROJECT COSTS/EXPENSES		2
	DETAILS OF IMMOVABLE PROPERTY TO BE CONSTRU	STATEMENT OF ASSETS AND LIABILITY		DETAILS OF SECURITY OFFERED		BUSINESS EMPLOYMENT INFORMATION		
	LOAN REQUEST	LOAN REQUEST		LOAN REQUEST		LOAN REQUEST		4
	DETAILS OF FINANCIAL WORTH OF THE APPLICANTS	PURPOSE OF LOAN		DETAILS OF THE COURSE / STUDY		ADDITIONAL INCOME		
	ADDITIONAL DETAILS OF BANK ACCOUNTS	Type of LOAN -Hypothetication/MortGage		DETAILS OF FINANCIAL WORTH OF THE PARENT / GUARD		TAX INFORMATION		
	DETAILS OF EXISTING LOANS			DETAILS OF EXISTING LOANS		BANK REFERENCES		2
				ADDITIONAL DETAILS OF BANK ACCOUNTS OF THE PARE		ACCOUNTANT Details		
	PROPOSED / PREFERRED REPAYMENT	PROPOSED REPAYMENT		PROPOSED / PREFERRED REPAYMENT AND PAYMENT OF		Additional information		3
	PROCESSING FEE / ADVOCATE'S / VALUER'S FEES DETAILS					FINANCIALDATA		
	REFERENCES (AT LEAST TWO) - Names, addresses and telephone nos.					TECHNICAL SERVICE PROVIDER		
	DOCUMENTS REQUIRED (FOR APPLICANTS & GUARA	DOCUMENTS REQUIRED		DOCUMENTS REQUIRED		DOCUMENTS REQUIRED		4
	DECLARATION	DECLARATION		DECLARATION		DISCLOSURE AGREEMENT		3
								23
Discussion & Verification		Discussion & Verification		Discussion & Verification		Discussion & Verification		
	Reason of loan	Reason of loan		Reason of loan		Reason of loan		4
	Nature of Loan	Nature of Loan		Nature of Loan		Nature of Loan		4
	Annual Income	Annual Income		Family Income		Annual Turnover		2
	Employment	Employment		Type of education loan		Employment		3
	Credit worthiness	Credit worthiness		Credit worthiness		Credit worthiness		4
		Description of car		Fee details		Turnover expected		
	Clearance certificate	Purchased with dealer or company		Admission letter		Clearance certificate		2
		Mode of purchase				Previous loan history		
	Legal papers	Legal papers				Legal papers		3
		Insurance offering				Business period		
								22
Field Investigation		Field Investigation		Field Investigation		Field Investigation		
	Existence of land	Registration				Infrastructure Checking		0
	Value of land	Car Model				For Investment /Working capital		0
	Land credibility	Car year				Legal Existence on all Properties		0
		New/Old						0
		Insurance						0
Loan Sanction		Loan Sanction		Loan Sanction		Loan Sanction		
	Return on Income	Return on Income		Return on Income		Return on Turnover		3
	Credit Appraisal	Credit Appraisal		Credit Appraisal		Credit Appraisal		4
	Eligible Amount	Eligible Amount		Eligible Amount		Eligible Amount		4
	Security analysis	Security analysis		Security analysis		Security analysis		4
	Tenure of loan	Tenure of loan		Tenure of loan		Tenure of loan		4
	EMI amount	EMI amount		EMI amount		EMI amount		4
	Mode of payment	Mode of payment		Mode of payment		Mode of payment		4
	Interest rates	Interest rates		Interest rates		Interest rates		4
	Processing Fee	Processing Fee		Processing Fee		Processing Fee		4
	Validity of sanctioning loan	Validity of sanctioning loan		Validity of sanctioning loan		Validity of sanctioning loan		4
	Add - On schemes	Add - On schemes		Add - On schemes		Add - On schemes		
								39
Submission of property documents -legal verification		Submission of property documents -legal verification		Submission of property documents -legal verification		Submission of property documents -legal verification		
	Property document	Driving licence				Property document		2
	Clearance certificate					Clearance certificate		2
	Previous History of loan	Previous History of loan		Previous History of loan		Previous History of loan		4
	Proof of residence (Utility bills)	Proof of residence (Utility bills)		Proof of residence (Utility bills)		Proof of Address (Utility bills)		3
		Road tax		Letter of admission				
		Hypothecation Agreement.		Letter of fee detail				
		Arrangement Letter						
		Registration book						
		Insured certificate						
	Collecting Collaterals	Collecting Collaterals		Collecting Collaterals		Collecting Collaterals		4
								15
Valuation & Loan agreement signing		Valuation & Loan agreement signing		Valuation & Loan agreement signing		Valuation & Loan agreement signing		
	Property analysis	Taxation		Foreign exchange agreement		Property analysis		
	Market price analysis	Registration						
	Balance-Payment evidence collection	Balance-Payment evidence collection		Balance-Payment evidence collection		Balance-Payment evidence collection		4
	Declaration	Declaration		Declaration		Declaration		4
								8
Disbursement		Disbursement		Disbursement		Disbursement		
	Part/full disbursement	Part/full disbursement		Part disbursement		Part/full disbursement		3
	Issuing cheque	Issuing cheque		Issuing cheque		Issuing cheque		4
								7

Figure 2. Process flow of various Loan Products and its Cross cutting concerns

Table 1. Task Wise Reuse: Loan Process

Aspects	Number of Loan Processes used	No of times the aspect identified in various Loan processes	Task wise Reuse (TWR) (%)
a1	**4**	**3**	**75**
A2	**4**	**2**	**50**
A3	**4**	**2**	**50**
A4	**4**	**4**	**100**
A5	**4**	**2**	**50**
A6	**4**	**3**	**75**
A7	**4**	**4**	**100**
A8	**4**	**3**	**75**
B1	**4**	**4**	**100**
B2	**4**	**4**	**100**
B3	**4**	**2**	**50**
B4	**4**	**3**	**75**
B5	**4**	**4**	**100**
B6	**4**	**2**	**50**
B7	**4**	**3**	**75**
D1	**4**	**3**	**75**
D2	**4**	**4**	**100**
D3	**4**	**4**	**100**
D4	**4**	**4**	**100**
D5	**4**	**4**	**100**
D6	**4**	**4**	**100**
D7	**4**	**4**	**100**
D8	**4**	**4**	**100**
D9	**4**	**4**	**100**
D10	**4**	**4**	**100**
e1	**4**	**2**	**50**
e2	**4**	**2**	**50**
E3	**4**	**4**	**100**
E4	**4**	**3**	**75**
E5	**4**	**4**	**100**
F1	**4**	**4**	**100**
F2	**4**	**4**	**100**
G1	**4**	**3**	**75**
G2	**4**	**4**	**100**

Table 2. Sub-Process Wise Reuse: Loan Process

Loan Process			
Sub Process	No. of Times identified Aspects Reused in all sub process of various loan processes	Total no. of steps in involved in all sub process of various loan processes	Sub-process wise Reuse(SWR) in percentage
1	23	49	46.93
2	22	34	64.70
3	0	11	-
4	39	44	88.63
5	15	24	62.50
6	8	14	57.14
7	7	8	87.50

Table 3. Shows Processes Wise Reuse Results of Various Banking Loan Processes

Different Types of Loan	Number of tasks involved in the loan Process	Number of tasks to be identified as core assets	Number of tasks to be developed after identifying core assets	total effort need to be done	effort saved by using core assets	Effort to be carried out
Home	45	33	12	100	73.33	26.66
Car	51	27	24	100	52.94	47.05
Education	40	26	14	100	65	35
Business	48	24	24	100	50	50
Total	184	110	74	100	59.78	40.21

4.2. Overall System Reuse (OSR)

The overall system reuse (OSR) of various loan processes is computed as the ratio of summation of Number of tasks involved in the each loan Process to summation Number of tasks to be identified as cross cutting tasks in each loan processes.

Overall System Reuse (LOAN PROCESS) = 110/184 => 59.77 %

The output of OSR metric depicts that 59.77% efforts are saved by using the cross cutting tasks as core assets.

5. Discussions

The table 3 shows results of the reusability in different levels of banking loan system. The below graphs from fig 3 to fig 8 are generated using the values of table 3.

5.1. Before Identifying the Aspects

The initial graph fig 3 illustrates the micro level steps or tasks involved in various loans processes before identifying the crosscutting concerns which illustrates the car loan having maximum number of tasks upto 51 and education loan having minimum number of tasks upto 40. The X and Y axis represents the types of loan and number of tasks involved in loan processes.

5.2. After Aspects Identified

The below graph from figure 4 to figure 7 gives a variations about the efforts involved in each loan processes after the cross cutting tasks (aspects) are identified. The x and y axis values of the graph denotes the number of tasks involved and efforts of loan processes (e.g. Home Loan (HL)).

From the above comparison which clearly states that 73 % of efforts involved are reduced in Home Loan (HL) processes.

The above graph illustrates that Figure 5 shows that 53 % of efforts involved are reduced in Car Loan (CL) processes after identifying the core assets.

The above comparison in Figure 6 shows that 65 % of efforts involved are reduced in education Loan (EL) processes by using the aspects.

The variation of the Figure 7 shows that 50 % of efforts are reduced in education Loan (BL) processes by using the aspects.

The above comparative graph Figure 8 illustrates that around 60% efforts are saved for various bank loan processes with help of the crosscutting concerns (aspects).

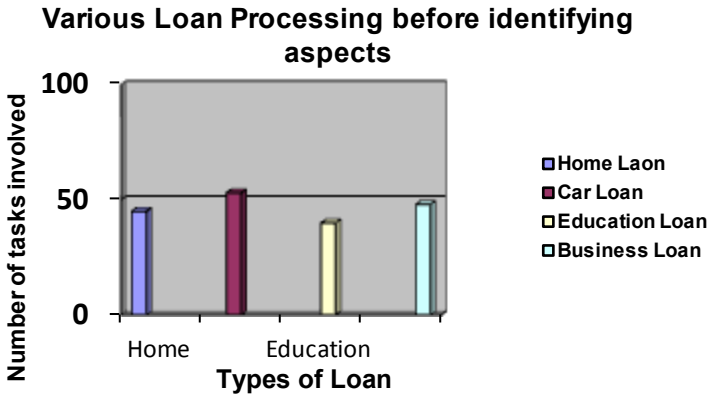

Figure 3. Number of tasks involved in various Loan Processes

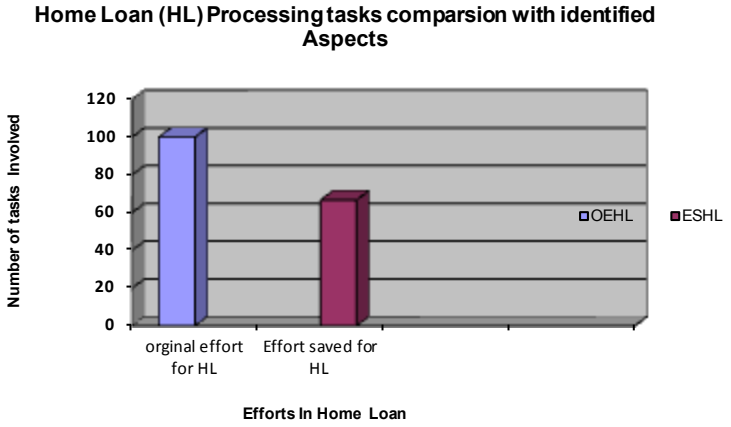

Figure 4. Variation in efforts of Home Loan Processes

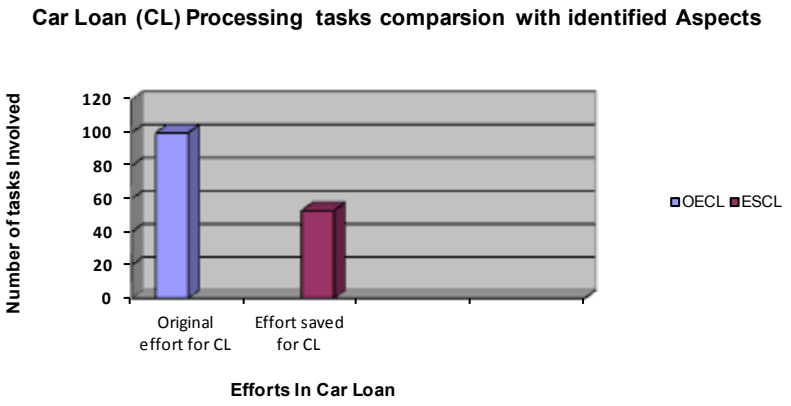

Figure 5. Variation in efforts of Car Loan Processes

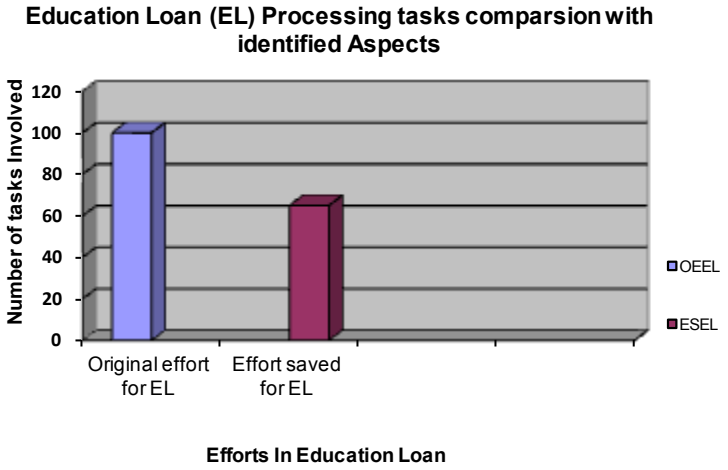

Figure 6. Variations in efforts of Education Loan

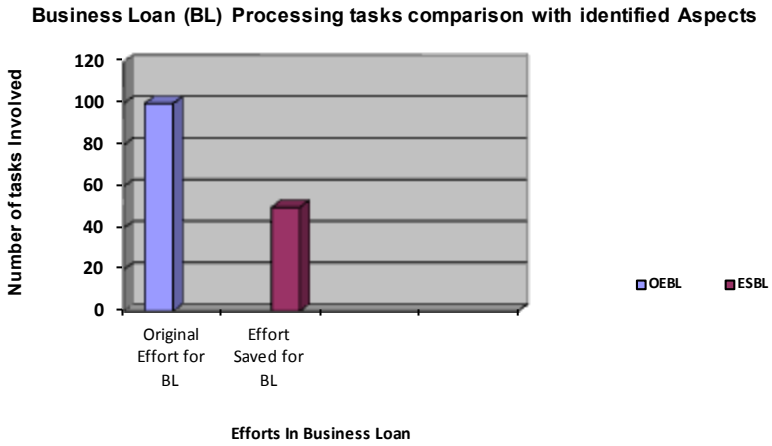

Figure 7. Variation in efforts of Business Loan

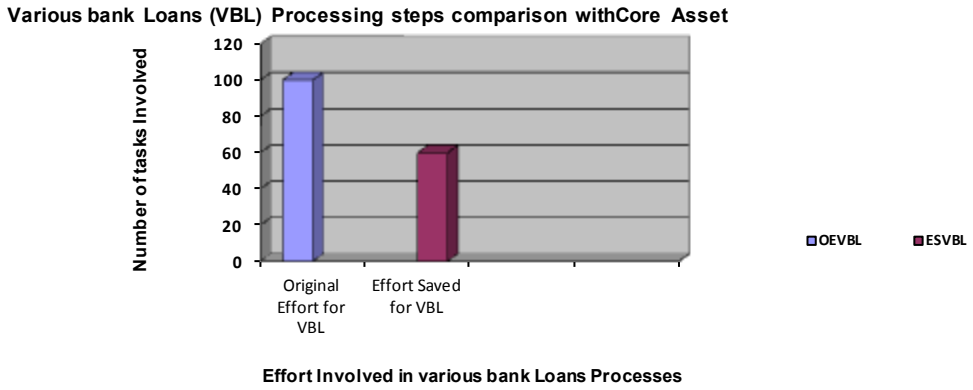

Figure 8. Effort saved by aspects for the various bank loan processes

6. Conclusions

Reusability is one of the prominent factors to improve the quality of any software systems. To achieve this goal, we propose a process flow based design model that uses aspect oriented approach. The proposed model starts by defining the tasks flow of processes, after that the cross cutting tasks are identified and separated it from the original process flow. The output of phase II of this model, used to compute the reusability at different levels of processes of entire system by using the proposed metrics and reported with results which shown that how the reusability of the system has achieved. This model is validated by banking loan system to verify its functionality on various phases. The results of applying this proposed model on loan system shows that amount of effort involved in the overall loan system is greatly reduced. Future work of our proposed model will contribute on validating the various banking systems like deposits, card and so on.

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